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CHARACTERIZATION STUDY OF NATURAL SAND, QUARRY DUST, WASTE PLASTIC (LDPE) TO BE USED AS A FINE AGGREGATE IN CONCRETE

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ABSTRACT

The scope of this study is to enhance the industry understanding the sustainable utilization of quarry dust, and to identify any gaps in current knowledge. The term sustainable utilization implies the use of quarry dust to their full potential to meet the needs of the present, while at the same time conserving natural resources and finding ways to minimize the environmental impacts associated both with quarry fines production and use. The addition of fine quarry dust with ldpe as waste plastic in concrete resulted in improved matrix densification compared to conventional concrete. Matrix densification has been studied qualitatively through petro graphical examination using digital optical microscopy. The materials were studied using XRD, SEM, E-DAX for natural sand, quarry dust and waste LDPE. This research has been motivated by the economic and environmental concerns over the disposal of wastes with the costs of traditional engineering materials.

Key words: Natural sand; quarry dust; waste plastic, XRD, SEM analysis.

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1. INTRODUCTION

Research has been done to investigate the use of quarry fines in various concrete applications. The International Center for Aggregates Research (ICAR) identified the use of micro fines (particles below 75 µm) in concrete. Studies suggested that artificial fine aggregate mortars with high fines content had higher flexural strength, improved abrasion resistance, higher unit

weight and lower permeability due to filling of pores with micro fines. Hence concrete can be manufactured using all of the aggregate, including micro fines from 7 to 18% without the use of admixtures (Ahn and Fowler, 2001)[9]. Hanson considered structural concrete (Craig-yr-Hesg) using 12% unseparated sandstone quarry fines. The product is being sold as standard C35 strength concrete (35 N/mm2). However results showed that the strength of the ultimate product would be considerably higher than 35 N/mm2 after 28 days. Hence, it was put forth that, if the filler material was to be replaced , and then much higher content of the coarser grained material have to be mixed , while retaining the desirable strength value (Lamb, 2005)[6]. Galetakis and Raka (2004) [7] studied the effect of varying replacement proportion of sand with quarry dust (20, 30 and 40%) on the properties of concrete in both fresh and hardened state. Saifuddin (2001)[8] studied the influence of partial replacement of sand with quarry dust and cement with mineral admixtures on the compressive strength of concrete (Gambhir, 1995), whereas Celik and Marar [10] investigated the effect of partial replacement of fine aggregate with crushed stone dust at different percentages in the properties of fresh and hardened concrete . It is worthy to consider that the hardened concrete properties as tensile and flexure strength can be increased by incorporating closely spaced fibers. These fibers may arrest the propagation of micro cracks, resulting in delay of onset of tensile cracks and enhancing the tensile strength of the material. (Zainab Z. Ismail, Enas A. AL-Hashmi, 2007)[5]. The study carried out by B.V.Bahoria, D.K.Parbat (2013)[1],[2],[3],[4] on M20 concrete revealed that the optimum modifier content as 6% the strength was found to be comparable with the conventional concrete. From the test results it was observed that the compressive strength value of the concrete mix increased with the addition of quarry dust and waste plastic fibers as modifier.

2. RESEARCH SIGNIFICANCE

The main objective of the present work was to systematically study the effect of characterisation properties of natural sand, quarry dust & waste plastic (ldpe) .Waste plastics have been incorporated with a view to enhance mechanical properties of concrete. Durability measurements were quantified using cracked permeability and rapid chloride permeability test methods. Cracked permeability of concrete is an important measure determined in this study which provides an actual estimation on the permeability properties of concrete under stressed conditions. Powders of microfines were analyzed using the x-ray diffractometer Scanning electron microscope (SEM) imaging was performed on specially prepared microfine samples. Using SEM enabled the microfines to be seen at higher resolution than possible with an optical microscope.

3. MINERALOGY

Determining the effect that micro fines with different characteristics have on concrete performance can lead to a better understanding of the function of micro fines as a part of the concrete and the benefits or disadvantages that result from their inclusion. It is unwise to categorically allow the use of all manufactured fine aggregate particles in concrete without a careful analysis of their characteristics and effects on performance. Dust of fracture versus clay minerals in the very fine size fractions is a very important issue. The mineralogy, size distribution, shape, and texture of these aggregates may all influence concrete properties. Keeping this in mind the study of mineralogy of the materials used, all the three materials acting as fine aggregate i.e Natural sand (sample1); Quarry dust (sample2); Waste plastic (sample3) were tested for XRD, SEM-EDS and E-DAX .

3.1. X-Ray Diffraction

Characterizing the mineralogy (Jane Stewart, March 2006)[11] of the micro fines can be done in several ways. X-ray diffraction can be used to identify compounds and minerals present in powdered specimens such as micro fines. It can also be used to identify the presence or absence of clay. Alternatively, scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS) allows high resolution identification of elements and compounds present in prepared 2-D cross-sections of aggregate samples. In x-ray diffraction, x-rays are scattered by atoms in a pattern that indicates lattice spacing's of elements present in the material being analyzed. When the x-rays are in phase, they will give constructive interference and produce a wavelength peak in the x-ray diffraction pattern. By measuring the x-ray wavelengths over a wide range of angles, the interplanar spacing's of the material can be found. "In order to identify an unknown substance, the powder diffraction pattern is recorded with the help of a [diffractometer] and a list of [interplanar spacing's] and the relative intensities of the diffraction lines are prepared. These data are compared with the standard line patterns available for various compounds in the Powder Diffraction File (PDF) database" (Chatterjee, 2001)[12] this process can lead to a qualitative determination of the elements and compounds present in the substance analyzed. Figure1, 2, 3 shows the XRD of natural sand, quarry dust and waste plastic.

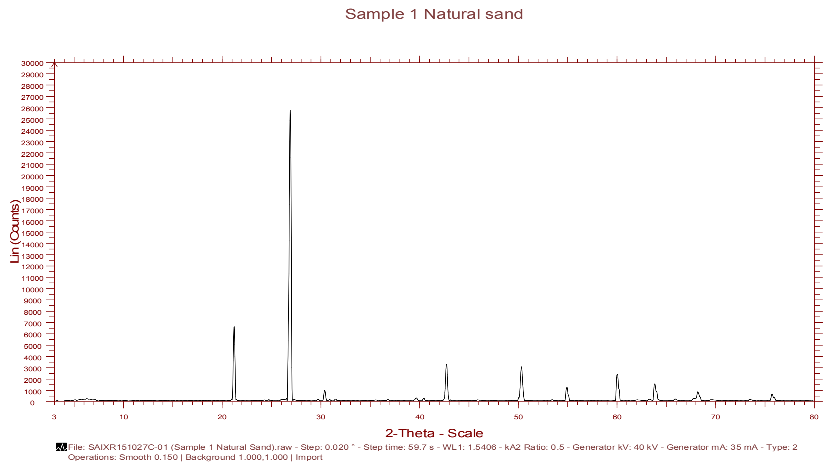


Figure 1 XRD of Natural sand

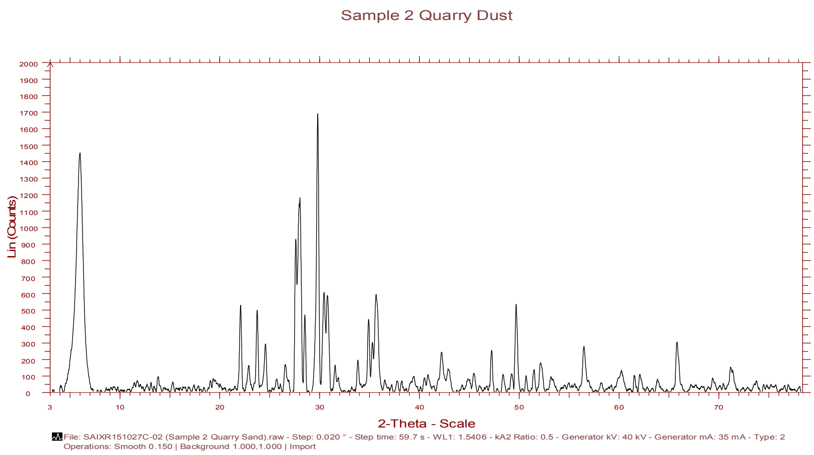


Figure 2 XRD of Quarry Dust

The results obtained are compared appropriately with the findings of (ICAR-107) and interpretation is done accordingly. As can be seen, similar materials are signified by similar composition, the natural sand & (NS01) was primarily composed of quartz along with the presence of calcite. Quarry dust & diabase or trap rock (TR02) contained graphite along with calcium oxides. The smallest particles are often where clays and other deleterious products often exist. In order to determine if any of the micro fines contained clay or other deleterious materials, samples containing only minus two micrometer particles were extracted using a sedimentation cylinder like that used in the hydrometer test. Samples were removed from the top of the sedimentation cylinder after six hours of settling. The water filled with microfines < 2 µm was then placed on a glass plate and left to dry. These samples were then exposed to the x-ray diffractometer. The minus two micrometer fractions of TR02 all contain minerals in the chlorite group. These particular minerals are micaceous. Mica, along with clays, is part of the phyllosilicates class of minerals. The inclusion of mica has been found to have undesirable effects on the performance of concrete. However, the effect is primarily dependent on the type of mica rather than how much mica is present (Muller 1971)[13].

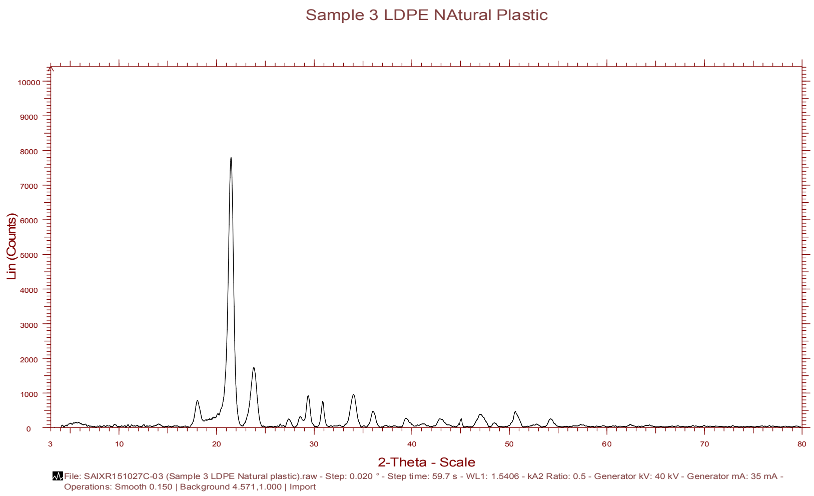


Figure 3 XRD of (LDPE) Waste plastic

It can be seen that LDPE is partly crystalline and partly amorphous structure due to the existence of sharp narrow diffraction peaks and broad peak. The d-spacing at $2\theta=19.8°$ is 4.479 Å. XRD diffraction for LDPE/nanoclay 2.5 phr and 5 phr composite at Figure 12 shows a crystalline pattern structure with the d-spacing value at $\theta=21.96°$ and $2\theta=21.32°$ are 4.043 Å and 4.163 Å respectively. The peak shifts to a higher angle compare with the LDPE, which correspond to the distance between interlayer decreases. The lower d-spacing value is at filler loading 2.5 phr. As the filler loading increases the composite become more crystalline due to the present of sharp narrow diffraction peaks.

3.2. SEM –EDS

SEM coupled with EDS can be an effective tool for visually examining a particle that is too small to be seen under an optical microscope. The SEM works by aiming an electron beam at the surface of the specimen. When the electron beam strikes a solid object, the electrons are either scattered or absorbed; the collection of these responses is what forms the SEM image. Any electrically conductive object can be microscopically examined in this manner (Sarkar et al., 2001). EDS detects the elements present in a specimen based on the detection of x-rays emitted by that specimen. Each element has a characteristic emission from the electron beam

because of each element's characteristic energy position. The x-ray photons emitted by the specimen are collected by EDS and converted to a number of "counts" at each emission voltage. "The total number of counts for a particular element is proportional to the amount of that element present in the object". Magnified images taken with SEM can be analyzed to determine several factors that could possibly relate to the performance of micro fines in concrete. The SEM images for sample1, sample2, sample3 under various magnifications ranges are shown in figures as follows.

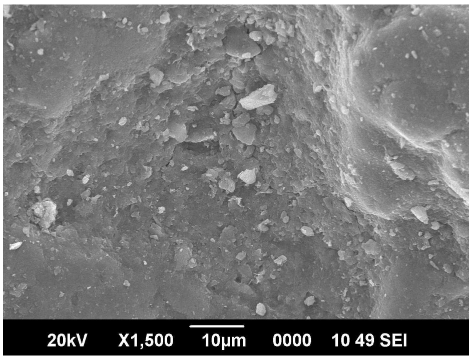


Figure 4 SEM-EDS for natural sand under X1500 magnification range

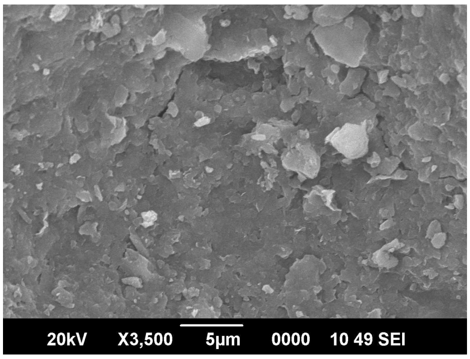


Figure 5 SEM-EDS for natural sand under X3500 magnification range

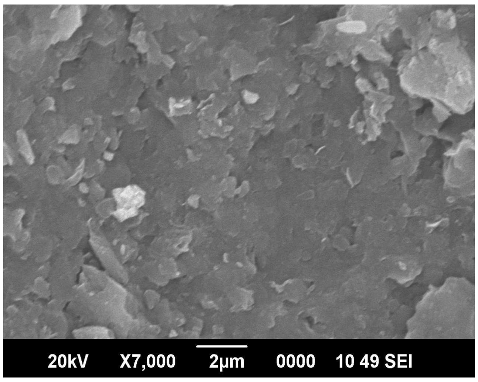


Figure 6 SEM-EDS for natural sand under X7000 magnification range

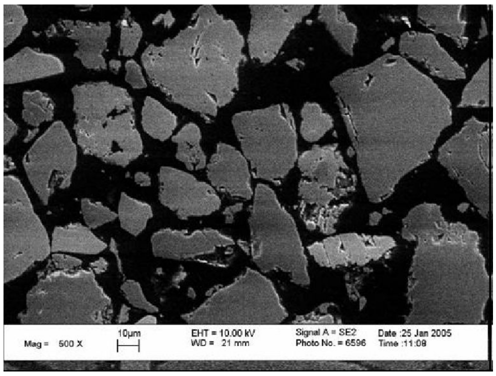


Figure 7 SEM image of NS01 (ICAR-107) at lower magnification x500

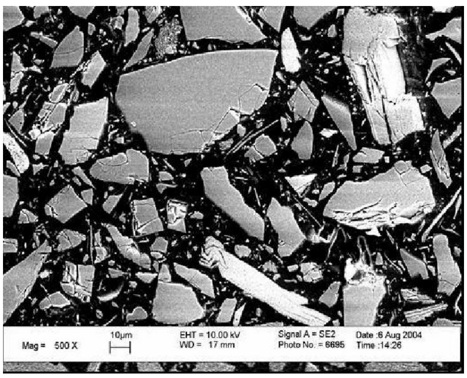


Figure 8 SEM image of TR02 (ICAR-107) at lower magnification

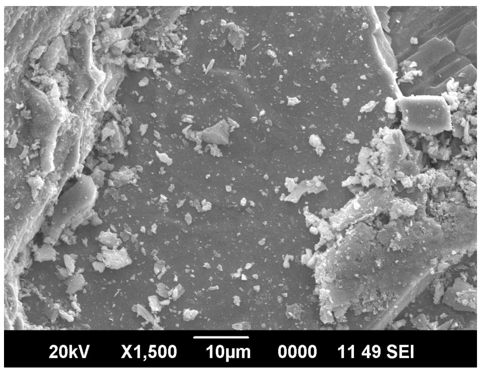


Figure 9 SEM-EDS for Quarry dust under X1500 magnification range

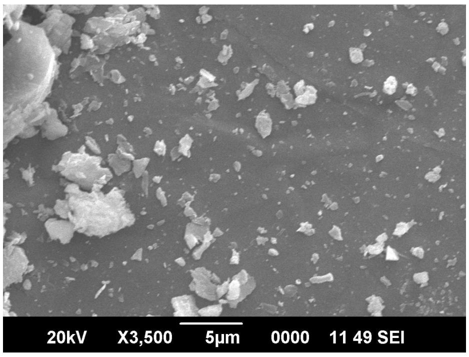


Figure 10 SEM-EDS for Quarry dust und X3500 magnification range

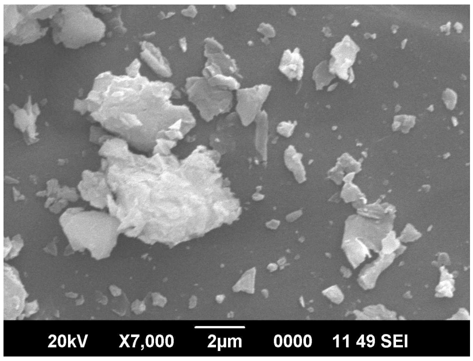


Figure 11 SEM-EDS for Quarry dust under X7000 magnification range

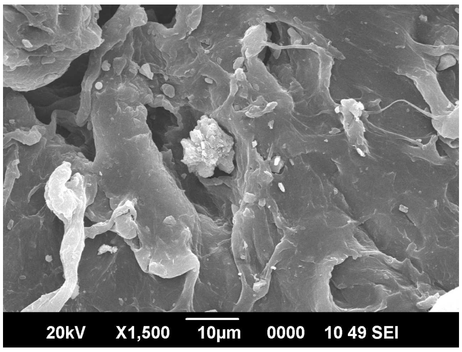


Figure 12 SEM-EDS for waste ldpe under magnification range

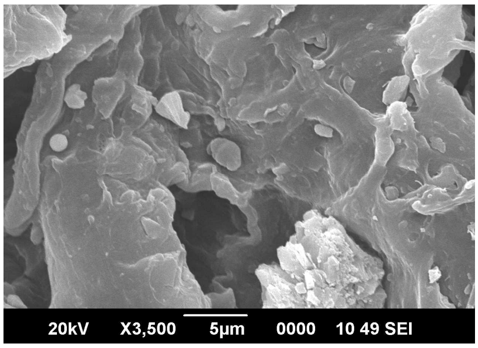


Figure 13 SEM-EDS for waste ldpe under X3500 magnification range

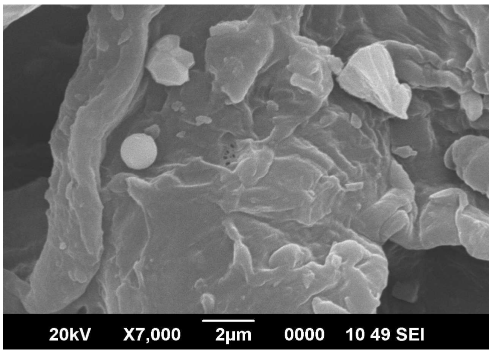


Figure 14 SEM-EDS for waste ldpe underX7000 magnification range

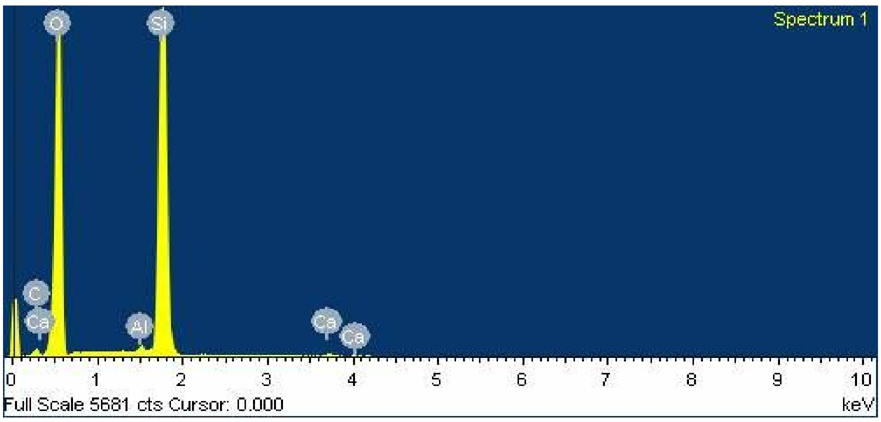


Figure 15 EDS Analysis of Natural sand

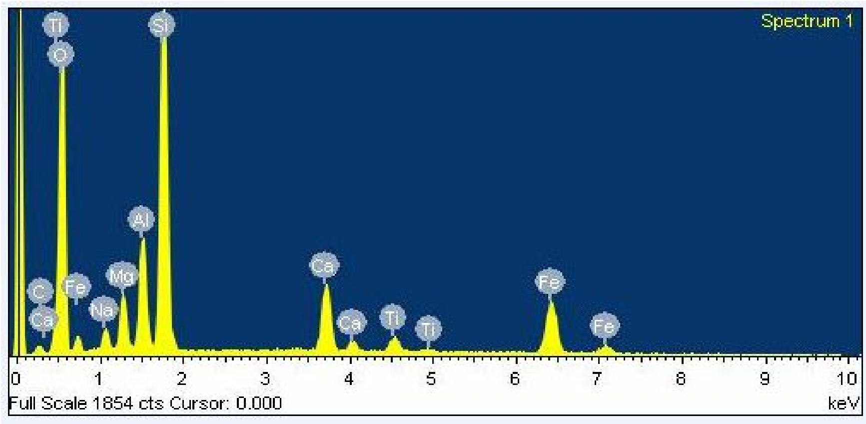


Figure 16 EDS Analysis of Quarry Dust

Table 1 Elements found in EDS Analysis of Natural sand, Quarry dust Natural sand

Element	**Weight%**	**Atomic%**
C K	4.03	6.13
O K	64.01	73.15
Al K	0.3	0.2
Si K	31.13	20.27
Ca K	0.53	0.24
	Quarry dust	
Element	Weight%	Atomic%
C K	2.78	5.29
O K	40.64	58.02
Na K	1.45	1.44
Mg K	3.09	2.9
Al K	5.34	4.52
Si K	18.53	15.07
Ca K	6.81	3.88
Ti K	2.28	1.09
Fe K	19.08	7.8

Table 1 Elements found in EDS Analysis of Waste plastic (LDPE)

Element	**Weight%**	**Atomic%**
C K	4.03	6.13
O K	64.01	73.15
Al K	0.3	0.2
Si K	31.13	20.27
Ca K	0.53	0.24
Totals	100	

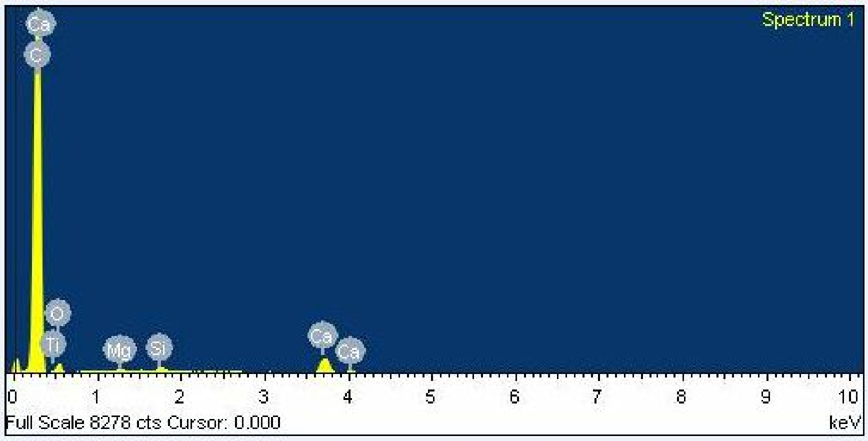


Figure 17 EDS Analysis of Waste Plastic (ldpe)

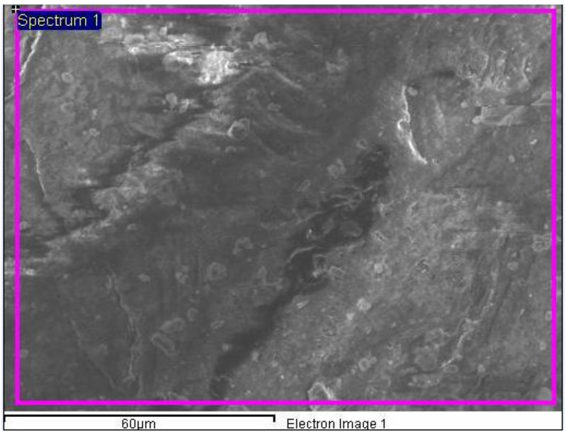


Figure 18 EDAX Image of Natural Sand

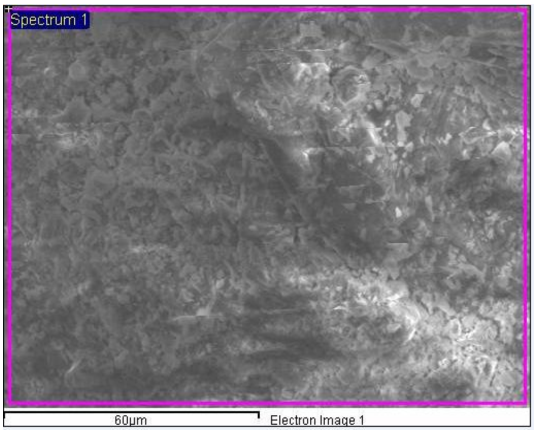


Figure 19 EDAX Image of Quarry Dust

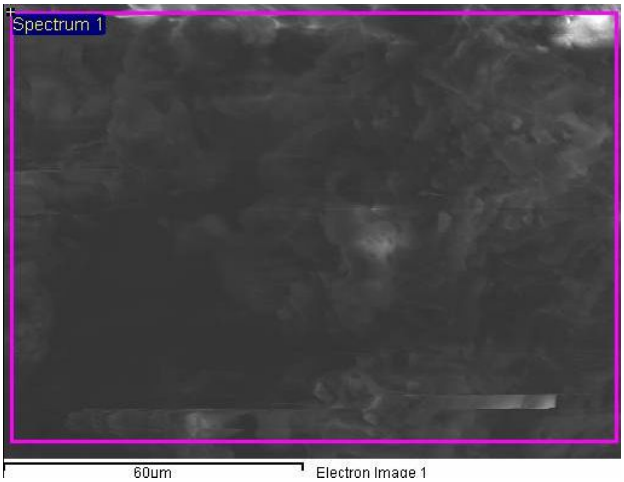
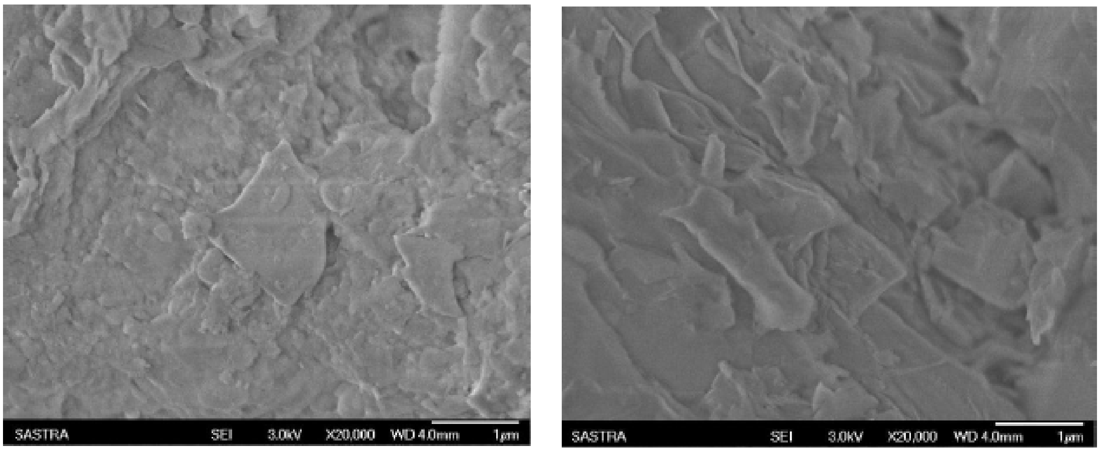


Figure 20 EDAX Image of Waste Plastic (ldpe)



(a) Controlled Concrete (b) Modified concrete

Figure 21 SEM images of concrete samples with Natural Sand and Quarry dust, waste plastic

From the Figure. 21(a) the major axis length was measured as 1.55 micrometer and the minor axis length was calculated as 1.5 micrometer. Here, the major axis length was almost equal to the minor axis length and the elongation was calculated as the ratio of the major axis length to the minor axis length, which was 1.0. This indicates that the particles are circular in shape. The area of the particle was measured as 1.88 square microns and the perimeter was calculated as 4.87 microns. The roundness of the particle was calculated as 0.99, which represents that the particles are almost spherical in shape. This improves the workability of the concrete. Figures.21 (b) exhibits the SEM image of the sample with manufactured sand at the same magnification of 20000x. From the Figure, the major axis length was measured as 1.87 micrometer and the minor axis length was 0.55 micrometer. The elongation was calculated as 3.4. This indicates that the particles are elongated one. The area of the particle was measured as 1.03 square microns and the perimeter was calculated as 4.84 microns. The roundness of the particles was calculated as 0.55, which represents that the particles are angular in shape. They create better packing between the particles and reduce the porosity. Because of this, the strength and durability characteristics are improved. It is found that the minerals present in the samples are silica, calcium and oxides. Here the calcium reacts with silica and oxides, and produces the hydrated calcium silicates, which impart strength to the concrete at early and later periods. From Figure.21, it becomes evident that the concrete sample contains silica, calcium, alumina and oxides. The calcium reacts with alumina and oxides and produces tri calcium aluminate, which is the reason for early setting.

4. CONCLUSIONS

- The SEM images of natural sand shows that the surface is rough with presence of micro voids, whereas quarry dust particles are fine in nature with average size of 2 to 3micron. The images for ldpe shows that it is having lamellar, crystalline (fiber like) structure. It is not having porous structure. Due to lamellar structure, it increases the strength carrying capacity.
- For the conventional concrete, the area of the particle was observed to be as 1.88 square microns and the perimeter was found as 4.87 microns. The roundness of the particle was observed as 0.99, which represents that the particles are almost spherical in shape which is helpful in improving the workability of the concrete.
- The roundness of the particles for modified concrete was found as 0.55, which represents that the particles are angular in shape this creates better packing between the particles and reduce the porosity which in turn improves strength and durability characteristics.

- The EDS analysis of LDPE represents that there is no such element causing harm to the concrete and can be used effectively to reduce permeability and enhance strength.
- The cracked permeability test results showed that the addition of quarry dust and waste plastic improved permeation resistance of concrete. The reduction in permeability coefficient values was found to be up to 20.91% and the reduction was significant for M0-92-8 mix for all grades of concrete. From the chloride permeability test results it was found that the permeation resistance for modified concrete compared to natural sand concrete specimens increased to 20% . Thus it can be inferred that the quarry dust and waste plastic led to the improved pore structure leading to matrix densification.
- The study also signifies that the durability of concrete is dictated due to initiation of micro cracks upon initial stress applied and becomes adverse due to capillary movement of water.

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